FAILED RETRIEVAL ATTEMPTS FOSTER GENERATION OF NOVEL RESPONSES

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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August 2014

Major Subject: Psychology

ABSTRACT

Novel, or uncommon, responses in idea generation, creative problem solving, and divergent thinking are difficult to generate because they experience reduced memory accessibility caused by blocking or fixation from common, pre-potent responses. Research has demonstrated that fixation in problem solving can be alleviated through memory inhibition by reducing accessibility of pre-potent responses serving as incorrect answers. Based on this finding, the present investigation tested whether failed retrieval attempts, such as those used to demonstrate retrieval-induced-forgetting, could reduce accessibility of pre-potent responses and alleviate fixation in category generation, resulting in increased generation of novel responses. Three experiments demonstrated greater average novelty of generated members of categories that received impossible retrieval practice, in which participants failed to retrieve a member, than for those that did not. These results offer potential avenues of study into mechanisms for improving divergent thinking and creative problem solving.

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1. INTRODUCTION

Mental fixation in creative problem solving, idea generation, and divergent thinking arises when novel or creative responses are inaccessible due to overriding accessibility of pre-potent, common responses (Smith, 2003). It has been demonstrated that forgetting the misleading and irrelevant pre-potent responses can assist in overcoming mental fixation and facilitate problem solving (e.g., Angello, Storm, & Smith, 2014; Smith & Blankenship, 1989; Storm & Angello, 2010; Storm, Angello. & Bjork, 2011). Although these studies have shed light on the connection between keeping incorrect answers out of mind and successful problem solving, they have yet to demonstrate the benefit of forgetting of counterproductive information for idea generation or divergent thinking tasks. Because there is evidence that forgetting is useful in creative problem solving, it seems reasonable that this forgetting can also help improve the quality of idea generation, such as the ability to generate more novel, less dominant members of a category. An investigation into the forgetting mechanisms that can result in access to novel category members can also offer possible avenues for exploring the benefit of forgetting for various other types of problem solving that require overcoming fixation in creative idea generation, such as engineering design (e.g., Jansson & Smith, 1991) and clinical diagnostic decision making (e.g., Croskerry, 2003; de Vries, Witteman, Holland, & Dijksterhuis, 2010).

2. OVERCOMING FIXATION IN CREATIVE PROBLEM SOLVING

2.1 Introduction

It has been argued that creative problem solving and creative idea generation performance can improve with intuition, what is referred to as “a means of discovering basic truths without any conscious activity of the mind” (Bowers, Regehr, Balthazard, & Parker, 1990, p.73). Similarly, a moment of insight is typically associated with the subjective experience of an idea suddenly coming to mind without immediately prior conscious work. Consistent with this view, an explanation for the subjective experience of surprise following the discovery of a novel idea is that unconscious work was occurring outside of awareness to bring mental effort closer to the solution (e.g., Bowers et al., 1990; Dijksterhuis, 2004; Moss, Kotovsky, & Cagan, 2007; Seifert, Meyer, Davidson, Patalano, & Yaniv, 1995; but see Weisberg & Alba, 1981). The novel idea is then realized once attentional focus is shifted back toward the task. Pushing this idea further, some even argue for an “autonomous unconscious work” mechanism to move iteratively toward the solution. “It may ‘feel’ as if the answer is suddenly presented to consciousness, however, before the answer becomes conscious, the unconscious is clearly thinking about it. It is, as it were already approaching the target” (Dijksterhuis & Meurs, 2006, p. 137).

2.2 Incidental Hints

Research exploring theories of insight tends to focus on possible mechanisms that allow for work toward the correct solution. For example, studies have offered evidence for a means to overcome fixation, or blocking caused by incorrect solutions, by presenting incidental hints (e.g., Hattori, Sloman, & Orita, 2013; Moss et al., 2007; Seifert et al., 1995). Moss et al. (2007) demonstrated successful problem resolution (i.e., solving initially failed problems) following an incubation period, or a period of time spent away from the problem, when the solution was presented to problem solvers during incubation without their awareness of the solution's relation to previously unsolved problems.

According to the idea of opportunistic assimilation, Seifert et al. (1995) argued that initial failed attempts at solving a problem sensitize that problem. When an environmental cue that is relevant to the solution is encountered serendipitously, the cue may trigger enough unconscious activation of the solution to bring it to conscious awareness. Evidence for opportunistic assimilation includes studies that have found greater resolution of remote associate test (RAT; Mednick, 1962) problems or general-information questions after the actual solutions were presented in an incidental task (e.g., Moss et al., 2007; Seifert et al., 1995). A RAT problem includes three seemingly unrelated words, such as *manners*, *tennis, round*, and the RAT problem solution is a fourth word that is uniquely related to each of the three problem words (e.g., *table*). This problem recruits creative thinking because the most common associates for each problem word (e.g., *polite, ball, square*) are misleading and incorrect, and more distant, or “remote” associates must be generated for the problem words before converging on the solution. Dodds, Smith, and Ward (2002) and Smith, Sifonis, and Angello (2012) also presented incidental hints prior to attempts to re-solve RAT problems. The hints in these studies, however, were semantically related to the answers (e.g., *chair*), rather than the actual answers. These hints failed to improve resolution, which suggests a limitation of the opportunistic assimilation theory. That is, evidence to date only shows that incidentally presented solutions can trigger resolution, but that cues that are semantically related to solutions do not.

The incidental hint account for a means to overcome fixation does not require a mechanism such as autonomous unconscious work. However, it fails to account for successful creative problem solving in the absence of presented hints. Next I will consider the forgetting fixation explanation for overcoming fixation. Unlike both autonomous unconscious work and incidental hints, forgetting fixation accounts for facilitation in performance not because the solver was somehow brought closer to the solution but because the solver was able to move further away from the wrong answer.

2.3 Forgetting Fixation

Prior to the moment of insight, counterproductive thoughts can mislead or distract thinking away from an appropriate and useful novel idea. Smith (1995) described the perception of these attempts in which “we sometimes start spinning our mental wheels, that is, we work harder and harder at a frustrating problem, but succeed only in getting deeper into a mental rut” (p. 229). Forgetting the misleading information can help remove us from the mental rut and allow subsequent novel ideas to come to mind relatively easily when compared to the progress of generating poor ideas that continue to reinforce each other, pushing us deeper into the rut and further away from insight. The forgetting fixation hypothesis specifies that during a break, or time spent away from working on the problem, forgetting can take place for the fixating information that was blocking the problem solver from accessing the solution (Smith & Blankenship, 1989, 1991). This hypothesis, unlike the incidental hint account, does not rely on work bringing the problem solver closer to the solution. Instead, it simply explains how misleading and interfering information can be forgotten so that when the initially unsolved problem is reattempted following the break, productive work can occur incrementally without one becoming misled by irrelevant information.

Smith and Blankenship (1989, 1991) primed participants with incorrect answers, and demonstrated that previously unsolved problems were more likely to be resolved on a second attempt following an incubation interval—a break from problem solving, when compared with immediate attempts at resolving problems. Further support for the forgetting fixation hypothesis was shown by Smith and Blankenship (1989) with greater forgetting of incorrect answers associated with problems assigned to longer incubation intervals. Importantly, improvement in creative problem solving following the incubation period, in the absence of incidental hints, has been found only when participants were initially primed with incorrect answers (Smith & Blankenship, 1989, 1991; Vul & Pashler, 2007). These findings suggest that problem resolution should only occur when the wrong answer creates a mental block to hinder access of the correct answer. If problem solvers fail to access the correct answer without experiencing a mental block from fixation on the wrong answer, they most likely lack the fundamental knowledge to support the identification of the correct answer. According to these findings then, the incubation interval is only effective at facilitating problem solving when it allows for the forgetting of misleading information. According to the forgetting fixation explanation, the incubation interval does not help those participants who will never arrive at the answer consciously by allowing for autonomous unconscious work, nor does it provide opportunistic assimilation from external sources.

Under this forgetting fixation rationale, a novel idea can seem to suddenly appear in one's mind when the idea is relatively easily generated following the forgetting (putting aside, even temporarily) and inaccessibility of poor ideas that previously acted to block access to the novel idea and caused its generation to seem difficult and nearly impossible. Although, it might be necessary for the person attempting creative idea generation to have some understanding of which ideas are the poor ones that should be ignored. Some studies suggest that certain individuals are better at forgetting or actively suppressing irrelevant information (e.g., Aslan & Bäuml, 2011; Levy & Anderson, 2008; Storm & Angello, 2010). In the next section, I review work exploring retrieval inhibition as a potential mechanism of forgetting fixation in the creative problem solving domain.

2.4 Retrieval Inhibition

Storm and Angello (2010) tested for retrieval inhibition as a skill and individual difference by splitting participants based on high or low levels of retrieval-induced forgetting. Retrieval-induced forgetting (RIF; Anderson, Bjork, & Bjork, 1994) occurs when items that compete for access during a related retrieval task are less likely to be recalled on a subsequent test, when compared with control items. For example, participants may study category-exemplar word pairs such as *fruit banana; fruit orange; fruit guava; fruit mango; tree birch; tree elm; tree juniper; tree ash.* Then, participants are given the task to retrieve half of the exemplars, such as orange and mango, from half of the studied categories. In order to encourage competition from other fruits, participants are cued to retrieve target exemplars with the category and the first two letters of the target exemplar *(e.g., fruit or_____, fruit ma_____).* Participants are later tested on all of the studied exemplars with a surprise cued-recall final test.

Anderson et al. (1994) first observed RIF when non-target exemplars that belonged to the categories presented during the retrieval task, such as banana, were recalled less often than control exemplars that belonged to categories that were never presented during the retrieval task, such as birch and elm. They also found RIF only for the exemplars strongly associated with the presented category, like banana, and not for weakly associated non-target exemplars, such as guava. Anderson et al. argued that exemplars strongly associated with the category presented during the retrieval task are more likely to compete for access during retrieval and are inhibited so that target exemplars can be retrieved. This inhibition, then, is what causes the forgetting later observed on the final test (see also Anderson, 2003; Bjork, 1989; Storm, 2011; Storm & Levy, 2012). Competition-dependent retrieval-induced forgetting has also been demonstrated using list-wise directed forgetting instructions to manipulate the accessibility of the non-target items competing during the retrieval task (Storm, Bjork, &

Bjork, 2007). Storm et al. found greater levels of RIF for non-targets that were given instructions to be remembered prior to retrieval practice when compared with non-targets given instructions to be forgotten.

Storm and Angello (2010) reasoned that if inhibition is the source of RIF, in that forgetting selectively targets items that interfere with retrieval and compete for access, a similar selective retrieval inhibition process might also work to suppress irrelevant information in problem solving. Additionally, this inhibition could facilitate creative problem solving by helping push away common and stereotypical incorrect answers that are often sources of fixation. To test this prediction, Storm and Angello presented participants with incorrect associates prior to solving RAT problems.

Storm and Angello (2010) found that participants who demonstrated high RIF were more likely to overcome fixation and solve RAT problems for which they had previously been exposed to misleading associates. Low RIF participants, however, were less likely to overcome fixation. These results suggest that inhibiting misleading information that competes for access can be a useful skill in creative thinking. Storm et al. (2011) demonstrated additional support for the role of retrieval inhibition in facilitating creative thinking. They found evidence of problem-solving-induced forgetting following RAT problem solving. Experiment 1 showed that participants were more likely to forget misleading associates following RAT problem solving when compared with associates of problems that were never presented during RAT problem solving. Furthermore, the observed problem-solving-induced forgetting was not contingent on RAT problem solving success. Experiment 2 demonstrated that greater periods of time spent attempting to solve RAT problems resulted in greater problem-solving-induced forgetting, suggesting that the recruitment of inhibition to counter fixation becomes more likely as more time is spent attempting to solve the problem. Experiment 3 provided additional evidence that retrieval inhibition can be a useful skill in creative problem solving. They observed a positive correlation between the proportion of RAT problems correctly solved and the amount of problem-solving-induced forgetting observed on a separate set of RAT problems.

Recently, Koppel and Storm (2014) found that the time spent away from the decision problem allows for better forgetting of wrong answers similarly for high and low RIF individuals. This suggests that providing an incubation period appears to negate the need for retrieval inhibition. If retrieval inhibition enables access to creative solutions that are more likely to be blocked by misleading information, there should be instances in which actively attempting to inhibit memory of blockers facilitates problem solving.

2.5 Suppression-Induced Forgetting

Angello et al. (2014) tested whether fixation caused by memory blocking could be overcome on a word fragment completion task (e.g., Leynes, Rass, & Landau, 2008; Smith & Tindell, 1997), if the memory of each blocker, or wrong answer, was actively and intentionally suppressed using the Think/No-Think method (Anderson & Green, 2001). Before participants were instructed to solve single-solution word fragments (e.g., B _ G _ A _ E), participants studied misleading words that would later serve as negative primes (e.g., BRIGADE) that happened to be orthographically similar to word-fragment solutions (e.g., BAGGAGE). Angello et al. reasoned that if access to these misleading negative primes was reduced, participants should be more likely to solve the associated word fragments compared to those fragments that had been negatively primed without repeated memory suppression attempts of associated blockers.

Anderson and Green (2001) first observed suppression-induced forgetting on a cued-recall test that followed opportunities for repeated memory suppression. During an initial learning phase, participants studied cue-response pairs (e.g., *ordeal-roach*) and were tested to a criterion so that they could recall the response word when presented with its associated cue word. Next, participants conducted repeated memory suppression trials during the Think/No-Think phase. For some of the previously studied cue words, participants were asked to think of the corresponding response words (think items). For critical cue words, however, participants were instructed to prevent thoughts of the associated response words (no-think items). Later, when participants were tested for memory of the studied response words with either the original cue (e.g., *ordeal-*) or an independent probe (e.g., *insect-r*) significant levels of forgetting occurred for no-think items compared with baseline responses that had not received Think or No-Think trials. These results were also attributed to a retrieval inhibition mechanism that is recruited in order to prevent retrieval of the unwanted item (for a review, see Anderson & Huddleston, 2012).

Angello et al. (2014) had participants learn cue words (e.g., PLANET) that were paired with unrelated negative primes (e.g., BRIGADE). A subset of the cue words served as cues on No-Think trials, while the remaining cue words associated with negative primes were not assigned to No-Think trials. Following several Think/No-Think trials, participants were asked to solve word fragments. Across two experiments, they demonstrated a memory blocking effect (e.g., Leynes et al., 2008; Smith & Tindell, 1997), or impaired fragment completion rates for items corresponding to negative primes that had not been suppressed during No-Think trials. Under the assumption that repeated memory suppression causes memory inhibition for responses participants must continue to fail to retrieve, Angello et al. hypothesized that retrieval inhibition should nullify the effect of blockers and reduce the memory blocking effect, thereby allowing access to correct answers during word fragment completion. In Experiment 1, when participants were not explicitly reminded of negative primes during fragment completion, repeated memory suppression of primes did not nullify their blocking effect on word-fragment completion. In Experiment 2, however, when participants were instructed to explicitly recollect primes to help solve word fragments, memory blocking effects were significantly reduced by repeated memory suppression of primes. These results demonstrate a means to actively counter a specific type of fixation, one that is caused by conscious recollection of counterproductive information.

Angello et al. (2014) offered a possible explanation for why they failed to find elimination of memory blocking that was primarily due to implicit memory of negative primes. They explained that memory blocking was caused by a *perceptual* representation of negative primes; whereas repeated memory suppression was carried out for the *conceptual* representation of negative primes. The negative primes, or blockers, were encoded via creating an episodic association between the cue and the prime, presumably with participants relying on the semantic properties of the prime. For example, a participant learning that PLANET is the cue word for BRIGADE may think of an army of Martians marching through the mountains of Mars. Later, if PLANET appeared as a cue during a No-Think trial, the participant would need to suppress the memory of the imagined Martian army. However, even if the repeated memory suppression attempts were successful, the participant could still be implicitly primed to think that the fragment B _ G _ A _ E must have ADE as an ending based on the perceptual components of the blocker. It still remains to be shown, then, that implicitly caused fixation can be successfully overcome by retrieval inhibition.

3. OVERCOMING FIXATION IN IDEA GENERATION

3.1 Introduction

Unfortunately, when fixation is caused implicitly, and not by conscious recollection of counterproductive information, it can be difficult for people to overcome even when they are warned to avoid poor ideas (e.g., Jansson & Smith, 1991). Implicitly caused fixation has been shown when people are blocked by presented examples and can only generate ideas that conform to the examples (e.g., Jansson & Smith, 1991; Smith, Ward, & Schumacher, 1993). It could be possible that people were unaware of the influences that the presented examples seemed to be exerting on their work. This would explain why an instruction to avoid conforming to the examples would be ineffective because it is not possible to avoid something of which you are unaware. A mechanism such as memory inhibition that can reduce accessibility of dominant, pre-potent competitors can be a useful tool to help eliminate implicit fixation in idea generation.

3.2 Generating Novel Responses

Historically, creative individuals were believed to have different mental representations that could permit greater accessibility to novel responses (Mednick, 1962), thereby eliminating the need to reduce accessibility of dominant, pre-potent competitors. Originally, Mednick had hypothesized that highly creative individuals mentally hold several items equally in association with certain concepts (e.g., *chair*, *cloth*, *wood*, *leg*, *food*, *mabel* are all equally likely to be generated from the word *table*). In contrast, he predicted that less-creative individuals hold certain stereotypical items strongly associated with concepts and uncommon items weakly associated, or less likely to be retrieved in association, with certain concepts (e.g., more likely to respond with *chair* or *wood* than *leg* or *food*). This model for differing *associative hierarchies* has been tested recently by Benedek and Neubauer (2013).

Benedek and Neubauer (2013) failed to find differences in response hierarchies between individuals scoring high and low on divergent thinking and other types of creativity measures. Specifically, they found that both high and low creative individuals have a tendency to respond with common associates initially and then to respond with less common associates toward the end of the free association task. However, despite holding a stronger associative strength for common responses compared to less common responses, high creative individuals were still able to generate a greater number of uncommon responses, suggesting a possible individual difference in ability to overcome fixation from pre-potent, strongly associated responses. Benedek, Franz, Heene, and Neubauer (2012) found a positive correlation between performance on a cognitive inhibition task, random motor generation (Schulter, Mittenecker, & Papousek, 2010), and creativity measures of insight and idea generation ability. Taken together, these results provide correlational support for the theory that individual differences in cognitive inhibition and executive functioning are key components in creative thinking by reducing access to pre-potent responses, permitting generation of novel, uncommon responses.

3.3 Current Investigation

Can retrieval inhibition help people overcome fixation in idea generation? Will forgetting of dominant category members facilitate the generation of less dominant category members? The goal of this study is to test whether reducing access via retrieval-induced forgetting (Anderson, Bjork, & Bjork, 1994) of unwanted exemplars can aid in later generation of less dominant members of the category. It is predicted that more novel, less dominant, members will be generated for categories whose dominant members have been subjected to retrieval inhibition, resulting in reduced accessibility, during retrieval practice. Furthermore, it will not be necessary for retrieval practice to be successful in order to observe the facilitation of novel category member generation, similar to the phenomenon of retrieval-induced forgetting for pre-potent category members following unsuccessful retrieval practice attempts (Storm, Bjork, Bjork, & Nestojko, 2006; Storm & Nestojko, 2010).

Storm et al. (2006) demonstrated retrieval-induced forgetting for studied non-target members that were common members of the category with which they were studied (e.g., *fruit banana*). These studied common members were assumed to be pre-potent because they had recently been encoded and were thus expected to come to mind first and compete for retrieval access on a subsequent retrieval practice task. Importantly, and unbeknownst to themselves, participants were prompted to retrieve a nonexistent member of the previously studied category (e.g., *fruit ge*_____). This impossible retrieval task in which the two-letter member stems could not be completed with a member of the cued category resulted in later forgetting of non-target competitors that were previously studied (e.g., *banana*). Storm et al. argued that this forgetting was the result of an executive control inhibitory mechanism that targets unwanted competitors and reduces their retrieval accessibility in order to facilitate retrieval of wanted targets (Anderson, 2003). Furthermore, Storm et al. offered the observed retrieval-induced forgetting during failures to retrieve as support for retrieval inhibition being *strength-independent* and *competition-dependent* (see also Storm & Nestojko, 2010). The fact that forgetting of unwanted competing members occurred even when participants were unable to successfully retrieve and potentially strengthen a target supports the strength-independence of retrieval-induced forgetting. Additionally, the observed forgetting for common members that had been recently studied with the categories used during impossible retrieval practice is consistent with the competition-dependence attribute of retrieval-induced forgetting. This study will employ an impossible retrieval practice task in order to avoid strengthening successfully retrieved target members, resulting in a biased schema for subsequent category generation.

The current research design will include a within-subjects factor for whether categories will receive impossible retrieval practice or no retrieval practice. A subset of categories will receive possible retrieval practice in order to encourage retrieval attempts during retrieval practice trials (Storm et al., 2006; Storm & Nestojko, 2010). The first two experiments will measure the total number of members generated, as well as the dominance, or novelty, of generated members based on the norms generated for control categories that never receive retrieval practice. Novelty will be measured as the inverse proportion of participants generating that member, such that higher novelty scores will be assigned for items generated by fewer participants. All scores used for the reported analyses will be standardized by multiplying the score by 100/N. Using a combination of the novelty norms from the first two experiments, the third experiment will measure novelty for single member responses when participants are prompted to give a creative response. It is expected that novelty of generated members will be higher in all three experiments for categories that previously received impossible retrieval practice when compared with control categories.

4. GENERAL METHOD

4.1 Material and Design

Eight categories were taken from Storm et al. (2006). For each category, three possible two-letter stems were recruited from the original Storm et al. materials that were each unique and could be completed with existing members of the category (see appendix A). Additionally, for each category, three different two-letter stems were designed such that no possible member could be produced using the stem cue. This resulted in a slight modification of the original Storm et al. materials, given that they observed some possible member retrieval for certain impossible stem cues (see appendix B).

For each participant, four categories were assigned as *control* categories that were never presented during retrieval practice and only appeared during the category generation task. Two categories were assigned to receive *possible* retrieval practice, and the remaining two categories were assigned to receive *impossible* retrieval practice. Categories were counterbalanced between subjects such that each category appeared in each condition equally often. Each participant performed category generation one category at a time for all eight categories. Two control categories were always presented first, followed by two impossible categories, and two possible categories. The remaining control categories were presented last.

4.2 Procedure

Participants were run individually or in groups of up to eight people. They were instructed to complete retrieval practice trials with the stipulation that they would be completing fill-in-the-blank problems in which they would see a category followed by the first two letters of a member of the category and that they should write down the member that completes the stem on the sheet in front of them that consisted of numbered blanks. An example was given for a category that was not part of the experiment (*Tools: ha*______; *hammer* is the correct response). Participants were told to expect repetitions and that some of the items may be more difficult than others, but they were encouraged to spend the entire time attempting to think of the member. They were then presented with three continuous blocks of 12 items, each for five seconds. Of these 12 items, six were possible stems, three of which were paired with one category and three paired with a different category. The remaining six were unique impossible stems, three paired with one category and three paired with a different category. Each block presented items in a different semi-random order such that no more than two items belonging to the same category were presented subsequently. Participants were naïve to the fact that half of the stems were impossible to complete.

Participants were then asked to complete a difficult maze for five minutes as a distractor task. If they finished before the allotted time, they were given a different maze to complete. Most participants spent the entire time working on the first maze. Then, participants were told that they would be completing a separate second experiment in which they would be presented with a sheet of paper with a category name at the top.

They were asked to try to list as many members of the category as possible within the time interval. Participants generated members for eight different categories for one minute each. They were then debriefed and thanked for their participation.

5. EXPERIMENT 1

5.1 Participants

Fifty-two undergraduates (38 females) volunteered for credit in an introductory psychology course. Participants were treated ethically according to the IRB.

5.2 Results

According to a 2X4 mixed-factors ANOVA in which the within-subjects factor was type of retrieval practice and the between-subjects factor was counterbalancing condition, the proportion of trials for which participants gave any type of response during the retrieval practice trials differed significantly between possible and impossible trials, $F(1, 48)=609.75$, $MSE=0 .01$, $p<.001$. There was no main effect of counterbalancing condition on the proportion of answered trials, $F(3, 48)=0.41$, $MSE= 0.02$, $p>.05$. Additionally, the interaction between counterbalancing and type of trial was also nonsignificant, $F(3, 48)=2.71$, $MSE= 0.02$, $p>.05$. Participants provided responses, on average, on significantly more possible retrieval practice trials ($M=0.67$, $SE=0.02$) when compared with impossible trials ($M=.08$, $SE=0.01$), $t(51)=23.53$, $d = 252.04$, $p<.001$.

The control, possible, and impossible categories did not differ in the number of responses generated during the category generation task according to a 3X4 mixed-factors ANOVA, where the type of category was within-subjects and the counterbalancing condition was between-subjects, $F(2, 96)=0.07$, $MSE= 2.26$, $p>.05$. The control category resulted in an average of 8.9 responses ($SE=0.34$), the impossible category resulted in 9.0 average responses (*SE*=0.50), and the possible category resulted in 9.0 average responses (*SE*=0.37). There was also no main effect of counterbalancing condition on the number of responses generated, $F(3, 48)=2.45$, $MSE= 9.14$, $p>.05$.

The control, possible, and impossible categories differed in average novelty of generated responses according to a 3X4 mixed-factors ANOVA, where the type of category was within-subjects and the counterbalancing condition was between-subjects, $F(2, 96)=6.27$, $MSE= 77.22$, $p<.01$. The average novelty, according to a planned paired-samples t-test, for generated members belonging to control categories (M=26.16, SE=1.44) was significantly less than the average novelty of members belonging to impossible categories (M=32.09, SE=1.94), $t(51)=-2.14$, $d = -24.96$, $p<.05$. The difference between the average novelty of control categories and possible categories (M=30.35, SE=2.05) failed to reach significance, $t(51)=-1.55$, $p>.05$.

A follow-up analysis was conducted by excluding all responses generated for any of the three different category types (control, possible, impossible) that began with the possible two-letter stems used for that particular category (see Appendix C). Although there was a main effect of type of category on the number of responses generated according to a 3X4 mixed-factors ANOVA, where the type of category was within-subjects and the counterbalancing condition was between-subjects, $F(2, 96)=5.24$, $MSE= 2.28$, $p<.01$, follow-up paired-samples t-tests revealed no significant differences in the number of responses generated between possible categories (M=7.23, SE=0.39) and control categories (M=7.80, SE=0.31), $t(51)=-1.38$, $p>.05$. Similarly, the number of responses did not differ between possible and impossible categories (M=8.18, SE=0.48),

$t(51)=-1.29$, $p>.05$. There was also no main effect of counterbalancing condition on the number of responses generated, $F(3, 48)=2.32$, $MSE= 7.54$, $p>.05$.

When looking at average novelty scores with excluded responses that fit possible stems, the control, possible, and impossible categories differed in average novelty of generated responses according to a 3X4 mixed-factors ANOVA, where the type of category was within-subjects and the counterbalancing condition was between-subjects, $F(2, 96)=5.41$, $MSE= 97.21$, $p<.01$. The average novelty, according to a planned paired-samples t-test, for generated members belonging to control categories ($M=26.85$, $SE=1.47$) was significantly less than the average novelty of members belonging to impossible categories ($M=33.15$, $SE=2.07$), $t(51)=-2.14$, $d = -25.29$, $p<.05$. The difference between the average novelty of control categories and possible categories ($M=29.27$, $SE=2.28$) failed to reach significance, $t(51)=-0.83$, $d = -9.07$, $p>.05$.

If participants were generating any type of response during the impossible retrieval practice trials, it could be argued that those responses acted to block the pre-potent, common members during category generation. Alternatively, perhaps those participants who retrieved any type of response during impossible retrieval practice were also more likely to benefit from divergent thinking, thus resulting in increased novelty scores during category generation. Both of these explanations would not require an inhibitory mechanism to suppress pre-potent responses that interfered during impossible retrieval practice. In order to test these alternatives, a median split analysis, based on the number of responses provided during impossible retrieval practice trials (for a similar analysis, see Storm et al., 2006), was conducted on the novelty scores generated.

Twenty-six participants, roughly half of the 13 from each of the four counterbalancing conditions (n = 8, 5, 8, 5), failed to retrieve any response during impossible retrieval practice trials. The remaining 26 participants responded during an average of 2.85 of the 18 impossible trials. Although there were clear differences in the number of responses generated during impossible trials between the two groups, those participants who responded during impossible trials did not differ in the average number of responses provided during possible trials (M=12.46, SE=0.53) when compared with the number of responses from those participants who failed to respond during impossible trials (M=11.73, SE=0.66), $t(50)=0.86$, $p>.05$.

Participants who responded during impossible trials did not exhibit a main effect of type of category on the number of responses that were generated during category generation, according to a one-way repeated-measures ANOVA, $F(2, 50)=0.62$, MSE= 7.81, $p>.05$. Similarly, participants who failed to respond during impossible trials did not exhibit a main effect of type of category on the number of responses that were generated during category generation, according to a one-way repeated-measures ANOVA, $F(2, 50)=0.69$, MSE= 8.69, $p>.05$. However, participants who responded during impossible trials did not exhibit a main effect of type of category on the novelty of responses that were generated during category generation, according to a one-way repeated-measures ANOVA, $F(2, 50)=0.65$, MSE= 166.19, $p>.05$. As expected, and in support of the retrieval inhibition explanation, participants who failed to respond during impossible trials did exhibit a main effect of type of category on the novelty of responses that were generated during category generation, according to a one-way repeated-measures ANOVA, $F(2, 50)=4.50$, $MSE= 167.90$, $p<.05$. A paired samples t-test confirmed that, for these participants, average novelty was significantly lower for generated members belonging to control categories ($M=23.67$, $SE=1.75$) than the average novelty of members belonging to impossible categories ($M=34.39$, $SE=2.72$), $t(25)=-2.76$, $d = -54.56$, $p<.025$. The difference between the average novelty of control categories and possible categories ($M=28.10$, $SE=2.77$) failed to reach significance, $t(25)=-1.23$, $d = -13.94$, $p>.05$.

5.3 Discussion

The results confirmed the prediction that categories for which participants receive impossible retrieval practice would result in greater novelty scores when compared with those categories that participants were never exposed to during retrieval practice. It is important to mention, as Storm et al. (2006) have pointed out, that one might expect the pre-potent members to receive even more strengthening in accessibility during the impossible retrieval practice trials since they are most likely to come to mind and compete for access. However, if this was the case, we would see an even greater number of common, less novel, responses generated when compared with those generated for control categories.

In addition, one might argue, as has been suggested as an alternative explanation for observations attributed to retrieval inhibition, that, although participants overtly generated very few responses on impossible trials, covertly, possibly unintentionally, accessed incorrect answers could become strengthened and potentially interfere with later recall of once pre-potent responses (see Storm et al., 2006). It is possible, perhaps, that the increase in novelty following failures to retrieve a correct response is actually due to an increased opportunity for divergent thinking, rather than due to an opportunity for retrieval inhibition. Experiment 2 was designed to test this alternative explanation. Control categories received an additional trial for category generation. The average novelty could then be compared between impossible categories and the second attempt for control categories. If the impossible retrieval practice trials are offering the chance for people to consider more novel members, then we should expect similar increases in novelty scores for control categories on the second generation trial.

6. EXPERIMENT 2

6.1 Participants

Thirty-two undergraduates (22 females) volunteered for credit in an introductory psychology course. Participants were treated ethically according to the IRB.

6.2 Method

The materials and design were the same as those in Experiment 1, except for two changes. First, the distractor task was increased to ten minutes in order to reduce accessibility to the responses participants may have been considering during impossible retrieval practice. Second, participants were asked to generate new members that had not been previously generated for an additional minute for each of the four control categories. These repeated category trials always came after the initial eight different categories had been presented. The first two repeated categories were presented *immediately* after both had been initially presented (e.g., *Insects*, *Trees, Insects, Trees*), while the final two repeated categories were those that had been presented first at the beginning of the generation task (*delayed repeated*).

6.3 Results

According to a 2X4 mixed-factors ANOVA in which the within-subjects factor was type of retrieval practice and the between-subjects factor was counterbalancing condition, the proportion of trials for which participants gave any type of response during the retrieval practice trials differed significantly between possible and impossible trials, $F(1, 28)=176.14$, $MSE=0 .03$, $p<.001$. There was no main effect of counterbalancing condition on the proportion of answered trials, $F(1, 28)=0.59$, $MSE= 0.04$, $p>.05$. Additionally, the interaction between counterbalancing and type of trial was also nonsignificant, $F(3, 28)=0.88$, $MSE= 0.03$, $p>.05$. Participants provided responses, on average, on significantly more possible retrieval practice trials ($M=0.62$, $SE=0.04$) when compared with impossible trials ($M=.08$, $SE=0.02$), $t(51)=13.35$, $p<.001$.

The control, possible, impossible, immediate repeated, and delayed repeated categories differed in number of responses generated according to a 5X4 mixed-factors ANOVA where the type of category was within-subjects and the counterbalancing condition was between-subjects, $F(4, 112)=119.55$, $MSE= 2.43$, $p<.001$. There was no difference in the number of responses generated for immediate repeated ($M=3.63$, $SE=0.43$) and delayed repeated categories ($M=4.27$, $SE=0.39$), $t(31)=-0.84$, $p>.05$. However, both the immediate repeated and delayed repeated categories differed in the number of responses generated when compared with the control ($M=9.45$, $SE=0.33$), possible ($M=9.70$, $SE=0.64$), and impossible categories ($M=9.11$, $SE=0.56$).

The average novelty of generated responses differed across conditions according to a 5X4 mixed-factors ANOVA, $F(4, 112)=22.92$, $MSE= 185.06$, $p<.001$. The average novelty, according to a planned paired-samples t-test, for generated members belonging to control categories ($M=29.67$, $SE=1.31$) was significantly less than the average novelty of members belonging to impossible categories ($M=34.60$, $SE=1.82$), $t(31)=-2.09$, $d = -18.06$, $p<.05$. However, the average novelty for members generated belonging to impossible categories was also significantly less than the average novelty for members generated during immediately repeated categories ($M=51.07$, $SE=4.35$), $t(31)=-3.45$, $d =$

-28.06, p<.001, in addition to being less than the average novelty for members generated during the delayed repeated categories (M=55.98, SE=4.09), $t(31)$=-4.38, d = -38.57, p<.001.

6.4 Discussion

Although the results replicated the initial finding in Experiment 1 in that larger novelty scores were observed following impossible retrieval practice when compared to category generation following no retrieval practice, the novelty scores were even larger during a second attempt at generating new members. It could be possible, then, that the failures during impossible retrieval practice trials are successful in providing an opportunity to consider alternative members, without recruiting an adaptive inhibitory mechanism to suppress pre-potent responses. Similar to the initial generation attempt in the control condition, the impossible retrieval practice trials may strengthen novel responses that are considered as possible targets during retrieval practice. Participants simply might have run out of time to list items that were strengthened and mentally generated during a given generation trial. Thus, the largest benefit for novel response generation was observed during the repeated trial, which is most likely due to an increase in time to list novel members.

The ability to access novel items, regardless of whether it is caused by retrieval inhibition or by an opportunity to think divergently, is a useful tool for tasks requiring creative thinking and problem solving. As discussed, implicitly caused fixation is often difficult to avoid, even when participants are instructed to do so (Jansson & Smith, 1991). It is possible that participants might ward off potential implicit fixation by working through failures to retrieve targets. The purpose of Experiment 3 was to apply the benefit of failed retrieval to a similar generation task in which participants are prompted to be creative. It is expected that creative responses will receive higher novelty scores for categories that receive impossible retrieval when compared with scores for categories that do not receive impossible retrieval practice.

7. EXPERIMENT 3

7.1 Participants

Thirty-two undergraduates (16 females) volunteered for credit in an introductory psychology course. Participants were treated ethically according to the IRB.

7.2 Method

The materials and design were the same as those in Experiment 1, except for one change. The category generation task was replaced with a single-item response task for each of the eight categories. The order of the categories remained the same. Participants were instructed to write the most creative member of the category. They were told that the creative member had to belong to the category. Participants were presented with each category for five seconds and asked to write their responses on a blank sheet of paper.

7.3 Results

According to a 2X4 mixed-factors ANOVA in which the within-subjects factor was type of retrieval practice and the between-subjects factor was counterbalancing condition, the proportion of trials for which participants gave any type of response during the retrieval practice trials differed significantly between possible and impossible trials, $F(1, 28)=243.88$, $MSE=0 .02$, $p<.001$. There was no main effect of counterbalancing condition on the proportion of answered trials, $F(3, 28)=0.30$, $MSE= 0.02$, $p>.05$. Additionally, the interaction between counterbalancing and type of trial was also nonsignificant, $F(1, 28)=1.63$, $MSE= 0.02$, $p>.05$. Participants provided responses, on average, on significantly more possible retrieval practice trials (*M*=0.68, *SE*=0.03) when compared with impossible trials (*M*=.09, *SE*=0.02), *t*(31)=15.41, *p*<.001.

The control, possible, and impossible categories differed only numerically in average novelty of generated responses according to a 3X4 mixed-factors ANOVA where the type of category was within-subjects and the counterbalancing condition was between-subjects, *F*(2, 56)=3.01, *MSE*= 546.74, *p*=.057. However, the average novelty, according to a planned paired-samples t-test, for generated members belonging to control categories (*M*=28.21, *SE*=2.62) was significantly less than the average novelty of members belonging to impossible categories (*M*=41.19, *SE*=5.48), *t*(31)=-2.30, *d* = -17.10, *p*<.05.

A follow-up analysis was conducted by excluding all responses generated for any of the three different category types (control, possible, impossible) that began with the possible two-letter stems used for that particular category. When looking at average novelty scores with excluded responses that fit possible stems, the control, possible, and impossible categories differed in average novelty of generated responses according to a 3X4 mixed-factors ANOVA, where the type of category was within-subjects and the counterbalancing condition was between-subjects, *F*(2, 56)=3.21, *MSE*=678.89, *p*<.05. The average novelty, according to a planned paired-samples t-test, for generated members belonging to control categories (*M*=28.60, *SE*=2.64) was significantly less than the average novelty of members belonging to impossible categories (*M*=44.72, *SE*=6.33), *t*(31)=-2.49, *d* = -18.77, *p*<.025. The difference between the average novelty of control categories and possible categories (*M*=39.76, *SE*=6.61) failed to reach significance, $t(31)=-1.82$, $d = -12.52$, $p>.05$.

7.4 Discussion

The increased novelty scores following impossible retrieval practice further extends the finding that a failed retrieval attempt can provide access to novel responses that might have otherwise been blocked by more common responses. If impossible retrieval practice trials allow for an inhibitory control mechanism, we might expect to see the most evidence of facilitated access to novel responses in instances where people are instructed not only to provide creative responses, but when they must overcome interfering information. Smith et al. (1993) showed evidence of induced fixation in an idea generation task even when participants were instructed to avoid conforming to presented examples. However, in our creative response task, participants were never presented with examples or fixating items. It was only in Experiments 1 and 2 where participants induced their own fixation by generating common category members where a significant difference in novelty scores was found across types of categories. It is possible that we might have observed larger differences in novelty scores between impossible and control categories had we presented common category members prior to the creative response task.

8. SUMMARY AND DISCUSSION

8.1 Summary of Results

Forgetting fixation via retrieval inhibition was proposed to account for the increased accessibility of novel category members during a category generation task. Participants failed at retrieving targets they believed to belong to a category when prompted with two letters that could not be completed with an actual member of the category (also see Storm et al., 2006) and later were more likely to generate novel category members. According to the theory of retrieval inhibition, even an impossible retrieval practice trial should produce competition from pre-potent, common, category members, which must subsequently be suppressed in order to attempt to retrieve targets mistakenly believed to actually exist (Storm et al., 2006). Similarly, in this set of experiments, it was predicted that during the failure to retrieve targets participants would recruit retrieval inhibition to suppress non-target members that would interfere and compete for retrieval (Anderson et al., 1994). This prediction follows from investigations in the role of retrieval inhibition in overcoming fixation in problem solving (e.g., Angello et al., 2014; Koppel & Storm, 2014; Storm & Angello, 2010; Storm et al., 2011). The aim of this study was to exploit the retrieval-induced forgetting of common category members during impossible retrieval practice trials in order to grant access to novel members on a future generation task.

8.2 Retrieval-induced Forgetting for Semantic Memory

It is important to point out that the effects of retrieval-induced forgetting, as measured by increased novelty scores, was observed in three experiments without the use of a study phase to ensure the existence of competing pre-potent non targets. To date, only one study, by Johnson and Anderson (2004), has provided evidence of retrieval-induced forgetting following retrieving category members with category-two-letter stem cues (Experiment 2) without a study phase to instill episodic fixation (however, see Levy, McVeigh, Marful, & Anderson, 2007 for retrieval-induced forgetting following a picture naming task). The evidence of these studies helps illustrate the potency of retrieval-induced forgetting, in that it can arise for semantic items and not only for competitors that interfere due to episodic memory.

8.3 Individual Differences

Storm and Angello (2010) demonstrated improved ability to overcome fixation and solve RAT problems for individuals who also demonstrated greater levels of retrieval-induced forgetting following retrieval practice for category members. This result suggests a link between the kind of cognitive control mechanisms that support retrieval and generating creative solutions in the face of avoiding interfering information. Experiment 1 and 2 of this study showed increased novelty averages of generated members following failures to retrieve category members. An increase in novelty of generated responses may be the result of reduced accessibility of common pre-potent responses that typically bock access to more novel responses. Benedek and Neubauer (2013) demonstrated a shared tendency for both high and low creative individuals, as measured by divergent thinking ability tests, to generate starting with most common responses, then later providing more novel, less common responses. They argued that highly creative thinkers are better able to efficiently generate both common and uncommon responses by working to make the best use of the time during the generation task, allowing for generation of more total members. Interestingly, across two experiments we did not find an increase in the total number of generated responses following impossible retrieval practice, which may suggest that participants did not need to make the most efficient use of their time to access less common responses following common ones that are typically generated first. The increased access to novel category members, instead, may be due to reduced access to common, pre-potent members.

Participants in Experiment 1 were split based on a median split for each counterbalancing on the number of responses provided during impossible retrieval practice trials. It was found that only those participants who failed to provide a response during impossible retrieval practice trials exhibited greater novelty scores following impossible retrieval practice trials. A similar analysis was performed by Storm et al. (2006) in order to counter the alternative explanation of interference from responses generated during impossible retrieval practice accounting for retrieval-induced forgetting of competing targets. Although our analysis is consistent with their findings, it can be interpreted that the participants who fail to retrieve an incorrect answer are more likely to spend time considering alternative members that fit the category but do not fit the two-letter stem. This non-inhibitory explanation, then, could explain why only these participants show increased novelty in generated responses. It will be informative to test applications of this type of "inside the box" thinking as a successful brainstorming tool, especially given the current consensus that deviant and divergent thinking is a useful creative skill (e.g., Benedek and Neubauer, 2013). In fact, past work has demonstrated the use of instructions that are aimed to constrain idea generation in preventing conformity to presented examples (Landau & Leynes, 2004).

8.4 Alternative Explanations

One problem with the retrieval inhibition explanation is that increased access to novel members does not necessarily require reduced access for common responses. For instance, an automatic spreading activation mechanism (e.g., Neely, 1977) may work to activate and prime novel category members during impossible retrieval practice trials, without requiring inhibitory suppression of common members. Quillian (1967) proposed the existence of a semantic network that spreads activation to related concepts to facilitate memory search and language comprehension. This type of network would make sense to account for the order of items generated because common members are more likely to share multiple connections with related items in the semantic network, and are thus more likely to be activated by priming (Collins & Loftus, 1975).

Automatic spreading activation (ASA; e.g., Neely, 1977) occurs rapidly and without intentional strategy or attentional resources, a mechanism that is very different than a retrieval inhibition mechanism recruited to overcome fixation and resolve response competition. However, according to theories involving ASA (e.g., Anderson, 1983; Collins & Loftus, 1975), activation decays rapidly in the absence of conscious attentional processing. Loftus (1973) directly tested spread time using a category exemplar retrieval task. She presented participants with a category name and one-letter-stem exemplar cue (e.g., fruit-A). Participants were told to name the first exemplar to come to mind using the cue. Loftus manipulated the number of intervening categories that followed an initial category presentation before that category was presented a second time. For example, in the lag 2 condition, a participant might be presented with (fruit-A, animal-D, color-B, fruit-P). She found that reaction time for the second presentation of the repeated category increased linearly as a function of the number of intervening filler categories. This suggests that any activation that spread to additional exemplars during the initial category presentation did not continue during the lag time. Furthermore, the actual spread time would have been brief in order to boost facilitation about a second later in the lag 0 condition, while providing less facilitation about three seconds later in the lag 2 condition. Interpolation, in fact, would show almost no facilitation, meaning no reduction in reaction time, for the second presentation of the repeated category at a lag 3 condition. Similarly, McNamara (1992) found that facilitation, reduced reaction time, during a lexical decision task caused by priming from a related word (e.g., maple primed syrup) disappeared at the lag 2 condition. In other words, when two filler words separated the prime and the related word, there was no reduction in reaction time for the related word compared to reaction times for trials without related primes.

If novel category members are primed and activated via spreading activation during the impossible retrieval practice task, it would require participants to actively make attempts to think back to incorrect items that were retrieved during impossible retrieval practice, given the evidence for the rapid decay of automatic spreading activation. Future work will need to explore the role of active and explicit attempts to recollect information retrieved during impossible retrieval practice and the benefit of retrieval-induced forgetting on the generation of novel responses. If this experimental design is to provide inspiration for the development of a brainstorming tool to aid creative idea generation and problem solving, the boundary conditions, such as whether participants must intentionally recollect responses retrieved during initial failures should be understood.

Experiment 2 also found greater novelty averages for categories that did not receive impossible retrieval practice but did receive an initial category generation opportunity. The result of Experiment 2 support a non-inhibitory explanation, such that the failed retrieval practice trials allow for divergent thinking opportunities because participants, during continue failure, have more opportunity to access a greater number of alternatives. According to this explanation, then, it is beneficial for participants to actively try to remember the responses that they retrieved during impossible retrieval practice trials during the category generation task, similar to the facilitation in accessing novel members that is observed during a second category generation attempt. Similar to the automatic spreading activation account for the results, opportunity to access a greater number of alternatives allows for increased access to novel, less common responses without reduced access to common, pre-potent responses.

One limitation with using a repeated category generation task that instructs participants to list new members is the task becomes more difficult by introducing increased output interference. Participants must think back to the previously generated members in order to avoid repeating the same members on the second generation task. Despite this difficulty, however, participants were still able to generate members that were, on average, more novel than both those generated initially and those generated following impossible retrieval practice. It could be that inhibitory processes are more likely to be recruited during difficult tasks that introduce more potential for output interference.

8.5 Future Directions

Future work should test whether individuals who show high levels of retrieval-induced forgetting are also better able to generate more novel members on a second generation attempt where they are told to avoid listing members that have previously been listed. According to work by Storm and Angello (2010), participants who are more likely to exhibit retrieval-induced forgetting for competitive non-targets should also be more likely to overcome fixation from irrelevant information. Applying this phenomenon to avoiding output interference in category generation could help shed light on the generality of the retrieval inhibition mechanism.

Furthermore, as Koppel and Storm (2014) have mentioned, greater ability for retrieval inhibition is only helpful for overcoming fixation in circumstances in which participants have difficulty forgetting blockers or misleading information. Perhaps when participants are thinking back to items that came to mind during impossible retrieval practice, they experience less difficulty in forgetting pre-potent responses. The benefit of failed retrieval attempts in accessing novel responses should be tested under conditions of time pressure, high stress, or increased fixation to see whether participants can recruit retrieval-induced forgetting of pre-potent responses to assist in generating novel responses.

It is possible that if participants are instructed to generate common responses we might also observe a similar difference in novelty scores. If it is the case that impossible retrieval practice trials result in retrieval-induced forgetting of pre-potent, common category members, these items should continue to experience limited accessibility and would be less likely to be generated even following a prompt to produce a common response. Alternatively, if impossible retrieval practice trials are not leading to reduced access for pre-potent responses but, instead, are resulting in greater access for novel responses given the opportunity for divergent thinking during failures to retrieve a target, we should not observe a difference in novelty between categories when participants are instructed to generate a common response.

8.6 Practical Applications

Experiment 3 demonstrated a trend toward people exhibiting better access to novel responses when given a creative prompt. However, this result should be tested with divergent thinking tasks and when common examples are provided to induce fixation to explore the extent of the increased accessibility for novel items.

A next step for applying this method to a more useful task could be to replace the categories used in these experiments with ad hoc categories (e.g., *cold things, heavy things*; see Barsalou, 1983). These categories consist of multiple sub categories, and it would be interesting to test for the role of retrieval-induced forgetting for an entire category that may be unwanted or unhelpful for the generation of novel members. In addition, alternative measures of increased access for novel responses should be explored, such as the variety of sub categories explored or the quality/utility of generated responses. Given the tendency for greater novelty to arise when participants fail to write incorrect responses during impossible retrieval practice, it may be the case that failures to retrieve wrong answers and failure to deviate too far from the definition of the target category can be helpful for producing useful novel responses, rather than any type of novel response.

Kohn and Smith (2011) showed evidence of *collaborative fixation* brought on by group brainstorming sessions. Investigations into the dynamics of retrieval-induced forgetting during group brainstorming can offer potential mechanisms to help offset collaborative fixation. Hirst and Echterhoff (2008) argued that *socially-shared retrieval-induced forgetting* (SS-RIF) can occur in contexts such as conversations between two or more people because silenced memories are more likely to occur, given conversational selective remembering and the limits of time and opportunity for the broad search required for retrieval-induced facilitation (see Chan, McDermott, & Roediger, 2006). In a study that used conversations between two participants to test the propagation of SS-RIF, Coman and Hirst (2012) observed changes in attitudes in support of euthanasia when retrieval-induced forgetting took place for arguments made against euthanasia practices. Of importance, they found this pattern following conversations between two participants with similar initial moderate attitudes regarding euthanasia. They attributed these results to the fact that people are less likely to assert alternative views when conversing with someone who holds similar attitudes as themselves. This silence of arguments that were previously selected against, which had undergone retrieval-induced forgetting, allowed continued forgetting to propagate from an initial setting to the conversation between participants. This change in context, they explained simulated people listening to a political debate in favor of euthanasia and later talking to people with similar views, such as close friends, about the arguments mentioned in the debate. Given that socially presented information also has the potential to influence collaborative idea generation, the social dynamics between innovators and creative problem solvers should be taken into consideration, especially since people are more likely to collaborate with and be influenced by thinkers sharing similar views (see also Coman, Stone, Castano, & Hirst, 2014).

The biasing influences of RIF on decisions and judgments are, in fact, more likely when listeners of a conversation question a speaker's expertise or credibility because they are likely to covertly selectively retrieve along with the overt selective retrieval of the speaker (Cuc, Koppel, & Hirst, 2007). Fortunately, conversations with other people holding divergent attitudes can prevent the propagation of retrieval-induced and its subsequent influence on attitudes. Coman and Hirst explain that this occurs because non-dominant speakers are motivated to initiate a broader and more complete retrieval in order to support arguments that conflict with the dominant speaker. Coman et al. (2014) provide additional support for motivated recall in overcoming retrieval-induced forgetting for relevant information following selective retrieval practice using the context of moral-disengagement when justifying atrocity.

Fortunately for creative thinking, however, questioning the ideas generated or monitoring the ideas generated for accuracy may produce beneficial SS-RIF and help creative thinkers overcome fixation collaboratively. It will prove informative to test for instances in which people selectively covertly retrieve when someone else is sharing an idea and whether SS-RIF can occur for common, unwanted ideas during brainstorming tasks.

Taking a break to help forget unwanted and interfering information may not always be a feasible option. The ability to limit access to unwanted information may allow creative solutions to come to mind. This study suggests that more time spent working to ward off future fixation can be helpful for generating less common, novel responses. If interfering information from recent experience or implicit assumptions can be forgotten while experiencing failure at a related task, increased time spent working, even when it appears to be counterproductive, may result in reduced biases and less fixation. If future work shows evidence for inhibitory control resulting in greater forgetting for incorrect competing responses with increased failures during problem solving, creative problem solvers might be more motivated to continue attempting the impossible.

REFERENCES

Anderson, J. R. (1983). A spreading activation theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *22*(3), 261–295.

Anderson, M. C. (2003). Rethinking interference theory: Executive control and the mechanisms of forgetting. *Journal of Memory and Language, 49*, 415–445. doi:10.1016/j.jml.2003.08.006

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 1063–1087. doi:10.1037/0278-7393.20.5.1063

Anderson, M. C., & Green, C. (2001). Suppressing unwanted memories by executive control. *Nature, 410*, 366–369.

Anderson, M. C., & Huddleston, E. (2012). Towards a cognitive and neurobiological model of motivated forgetting. In: R.F. Belli (Ed.), *True and false recovered memories: Toward a reconciliation of the debate*. New York, NY: Springer (pp. 53–120).

Angello, G., Storm, B. C., & Smith, S. M. (2014). Overcoming fixation with repeated memory suppression. *Memory*. Advance online publication.

Aslan, A. & Bäuml, K.–H.T. (2011). Individual differences in working memory capacity predict retrieval-induced forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 264–269.

Barsalou, L. W. (1983). Ad hoc categories. *Memory & Cognition, 11*(3), 211–227.

Benedek, M., Franz, F., Heene, M., & Neubauer, A.C. (2012). Differential effects of cognitive inhibition and intelligence on creativity. *Personality and Individual Differences, 53,* 480–485; doi: 10.1016/j.paid.2012.04.014.

Benedek, M., & Neubauer, A. C. (2013). Revisiting Mednick's model on creativity-related differences in associative hierarchies. Evidence for a common path to uncommon thought. *The Journal of Creative Behavior, 47*(4), 273–289.

Bjork, R. A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 309–330). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Bowers, K. S., Regehr, G., Balthazard, C., & Parker, K. (1990). Intuition in the context of discovery. *Cognitive Psychology, 22*(1), 72–110.

Chan, J.C.K., McDermott, K.B., & Roediger, H.L., III. (2006). Retrieval-induced facilitation: Initially nontested material can benefit from prior testing of related material. *Journal of Experimental Psychology: General*, *135*, 553–571.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82*(6), 407–428.

Coman, A., & Hirst, W. (2012). Cognition through a social network: The propagation of induced forgetting and practice effects. *Journal of Experimental Psychology: General*, *141*, 321–336.

Coman, A., Stone, C. B., Castano, E., & Hirst, W. (2014). Justifying atrocities: The effect of moral-disengagement strategies on socially shared retrieval-induced forgetting. *Psychological Science,* Advance online publication. doi: 10.1177/0956797614531024

Croskerry, P. (2003). The importance of cognitive errors in diagnosis and strategies to minimize them. *Academic Medicine, 78*(8), 775–780.

Cuc, A., Koppel, J., & Hirst, W. (2007). Silence is not golden: A case for socially shared retrieval-induced forgetting. *Psychological Science, 18*, 727–733.

de Vries, M., Witteman, C. L., Holland, R. W., & Dijksterhuis, A. (2010). The unconscious thought effect in clinical decision making: an example in diagnosis. *Medical Decision Making, 30*(5), 578–581.

Dijksterhuis, A. (2004). Think different: The merits of unconscious thought in preference development and decision making. *Journal of Personality and Social Psychology, 87*(5), 586–598.

Dijksterhuis, A., & Meurs, T. (2006). Where creativity resides: The generative power of unconscious thought. *Consciousness and Cognition, 15*(1), 135–146.

Dodds, R. A., Smith, S. M., & Ward, T. B. (2002). The use of environmental clues during incubation. *Creativity Research Journal, 14*(3-4), 287–304.

Hattori, M., Sloman, S. A., & Orita, R. (2013). Effects of subliminal hints on insight problem solving. *Psychonomic Bulletin & Review, 20*(4), 790–797.

Hirst, W., & Echterhoff, G. (2008). Creating shared memories in conversation: Toward a psychology of collective memory. *Social Research: An International Quarterly, 75*, 183–216.

Jansson, D. G., & Smith, S. M. (1991). Design fixation. *Design Studies, 12*(1), 3–11.

Johnson, S.K., & Anderson, M.C. (2004). The role of inhibitory control in forgetting semantic knowledge. *Psychological Science, 15*, 448–453.

Kohn, N. W., & Smith, S. M. (2011). Collaborative fixation: Effects of others' ideas on brainstorming. *Applied Cognitive Psychology, 25*(3), 359–371.

Koppel, R. H., & Storm, B. C. (2014). Escaping mental fixation: Incubation and inhibition in creative problem solving. *Memory*, *22*(4), 340–348.

Landau, J., & Leynes, P. A. (2004). Manipulations that disrupt generative processes decrease conformity to examples: Evidence from two paradigms. *Memory, 12*(1), 90–103.

Levy, B. J., & Anderson, M. C. (2008). Individual differences in the suppression of unwanted memories: The executive deficit hypothesis. *Acta Psychologica*, *127*(3), 623–635.

Levy, B.J., McVeigh, N.D., Marful, A., & Anderson, M.C. (2007). Inhibiting your native language: The role of retrieval-induced forgetting during second-language acquisition. *Psychological Science, 18*, 29–34.

Leynes, P. A., Rass, O., & Landau, J. D. (2008). Eliminating the memory blocking effect. *Memory, 16*, 852–872.

Loftus, E. F. (1973). Activation of semantic memory. *The American Journal of Psychology*, *86*(2), 331–337.

McNamara, T. P. (1992). Theories of priming: I. Associative distance and lag. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*(6), 1173–1190.

Mednick, S. A. (1962). The associative basis of the creative process. *Psychological Review*, 69, 220–232. doi:10.1037/h0048850

Moss, J., Kotovsky, K., & Cagan, J. (2007). The influence of open goals on the acquisition of problem-relevant information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33*(5), 876–891.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology:General*, *106*(3), 226–254.

Quillian, M. R. (1967). Word concepts: A theory and simulation of some basic semantic capabilities. *Behavioral Science*, *12*(5), 410–430.

Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., and Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared mind perspective. In R. Sternberg & J. Davidson (Eds.) *The nature of insight* (pp. 65–124). Cambridge, MA: MIT Press.

Schulter, G., Mittenecker, E., & Papousek, I. (2010). A computer program for testing and analyzing random generation behavior in normal and clinical samples: The Mittenecker Pointing Test. *Behavior Research Methods*, *42*(1), 333–341.

Smith, S. M. (1995). Getting into and out of mental ruts: A theory of fixation, incubation, and insight. In R. Sternberg & J. Davidson (Eds.), *The nature of insight* (pp. 121–149). Cambridge, MA: MIT Press.

Smith, S. M. (2003). The constraining effects of initial ideas. In P. Paulus & B. Nijstad

(Eds.), *Group creativity: Innovation through collaboration* (pp. 15–31). Oxford, England: Oxford University Press.

Smith, S. M., & Blankenship, S. E. (1989). Incubation effects. *Bulletin of the Psychonomic Society, 27*, 311–314.

Smith, S. M., & Blankenship, S. E. (1991). Incubation and the persistence of fixation in problem solving. *American Journal of Psychology, 104*, 61–87.

Smith, S. M., Sifonis, C. M., & Angello, G. (2012). Clue insensitivity in remote associates test problem solving. *Journal of Problem Solving, 4*(2), 28–49.

Smith, S. M., & Tindell, D. R. (1997). Memory blocks in word fragment completion caused by involuntary retrieval of orthographically related primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 355–370.

Smith, S. M., Ward, T. B., & Schumacher, J. S. (1993). Constraining effects of examples in a reative generation task. *Memory & Cognition, 21*, 837–845.

Storm, B. C. (2011). The benefit of forgetting in thinking and remembering. *Current Directions in Psychological Science, 20*, 291–295.

Storm, B. C., & Angello, G. (2010). Overcoming fixation: Creative problem solving and retrieval-induced forgetting. *Psychological Science, 21*(9), 1263–1265.

Storm, B. C., Angello, G., & Bjork, E. L. (2011). Thinking can cause forgetting: Memory dynamics in creative problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*, 1287–1293.

Storm, B. C., Bjork, E. L., & Bjork, R. A. (2007). When intended remembering leads to unintended forgetting. *Quarterly Journal of Experimental Psychology, 60*, 909–

915.

Storm, B.C., Bjork, E.L., Bjork, R.A., & Nestojko, J.F. (2006). Is retrieval success a necessary condition for retrieval-induced forgetting? *Psychonomic Bulletin & Review*, *13*, 1023–1027.

Storm, B. C., & Levy, B. J. (2012). A progress report on the inhibitory account of retrieval-induced forgetting. *Memory & Cognition, 40,* 827–843.

Storm, B. C., & Nestojko, J. F. (2010). Successful inhibition, unsuccessful retrieval: Manipulating time and success during retrieval practice. *Memory*, *18*(2), 99–114.

Vul, E., & Pashler, H. (2007). Incubation benefits only after people have been misdirected. *Memory & Cognition, 35*, 701–710.

Weisberg, R. W., & Alba, J. W. (1981). An examination of the alleged role of" fixation" in the solution of several" insight" problems. *Journal of Experimental Psychology: General, 110*(2), 169–192.

APPENDIX A

Category: Possible Responses
Fruits: **Le**mon, **Or**ange, **Pi**neapple
Drinks: **Wh**iskey, **Al**e, **Bo**urbon
Weapons: **Pi**stol, **Bo**mb, **Cl**ub
Professions: **Fa**rmer, **Nu**rse, **Pl**umber
Metals: **Si**lver, **Br**ass, **Go**ld
Fish: **Tr**out, **Gu**ppy, **Bl**uegill
Insects: **Ro**ach, **Mo**squito, **Gr**asshopper
Trees: **Re**dwood, **Sp**ruce, **El**m

APPENDIX B

Category: Impossible Two-Letter Stems

Fruits: an___, fl____, ge_______

Drinks: ce_____, na_____, oc___

Weapons: ow____, va__, fu___

Professions: vu____, ti_____, gi___

Metals: lo__, ja___, ve____

Fish: wu___, di______, ka______

Insects: sh__, wi___, sq____

Trees: aj___, pu______, te______

APPENDIX C

Experiment 1 Category Members and Novelty Scores

* Possible Responses

Professions

doctor	5.55556
lawyer	7.14286
teacher	7.14286
engineer	11.1111
psychologist	11.1111
police officer	12.5
*nurse	14.2857
accountant	16.6667
firefighter	16.6667
manager	20
banker	25
biologist	25
dentist	25
janitor	25
professor	25
actress/actor	33.3333
business	33.3333
chef	33.3333
chemist	33.3333
physical therapist	33.3333
scientist	33.3333
surgeon	33.3333
veterinarian	33.3333
architect	50
athlete	50
baker	50
*baseball player	50

coach	50
counselor	50
dancer	50
electrician	50
EMT	50
entrepreneur	50
*farmer	50
florist	50
*football player	50
geologist	50
judge	50
librarian	50
mechanical engineer	50
occupational therapist	50
pharmacist	50
physician	50
*plumber	50
politician	50
psychiatrist	50
sales clerk	50
secretary	50
sociologist	50
technician	50
therapist	50
trainer	50
waiter	50
writer	50

model	100
administrator	100
agent	100
analyst	100
anesthesiologist	100
anthropologist	100
archeologist	100
artist	100
assistant professor	100
associate professor	100
astronaut	100
astronomer	100
baby sitter	100
bagger	100
barista	100
*basketball player	100
beautician	100
blacksmith	100
brain surgeon	100
broom sweeper	100
bus driver	100
butcher	100
butler	100
car driver	100
cardiologist	100
cashier	100

CEO	100
CFO	100
chemical engineer	100
child psychologist	100
civil engineer	100
cleaners	100
clerk	100
clinical psychologist	100
computer analyst	100
computer programmer	100
congress member	100
construction	100
councilor	100
criminal justice	100
custodian	100
designer	100
diagnostician	100
dietician	100
director	100
driver	100
education	100
ER doctor	100
executive	100
executive assistant	100
*fashion designer	100
financial analyst	100
flight attendant	100
food service worker	100
forensic anthropologist	100
founder	100
garbage man	100
gardener	100

general manager	100
geographer	100
geothermal engineer	100
golfer	100
grocer	100
groundskeeper	100
guitarist	100
heart surgeon	100
historian	100
hostess	100
house keeper	100
HR	100
insurance agent	100
investor	100
IT	100
jailer	100
journalist	100
law enforcement	100
locksmith	100
magician	100
maid	100
maintenance	100
makeup artist	100
marketer	100
marketing	100
mathematician	100
mechanic	100
medical doctor	100
medical sergeant	100
medicine	100
military	100
minesweeper	100
mower	100
musician	100
nanny	100
navy psychologist	100

network administrator	100
neurologist	100
*nuclear engineer	100
*nutritionist	100
OBGYN	100
optometrist	100
orthodontist	100
paleontologist	100
paralegal	100
paramedic	100
pastor	100
pediatrician	100
physicist	100
pilot	100
*plastic surgeon	100
postal carrier	100
preacher	100
president	100
priest	100
principal	100
producer	100
radiologist	100
rancher	100
realtor	100
receptionist	100
researcher	100
restaurant manager	100
sales person	100
senator	100
singer	100
skydiver	100
small business owner	100
*soccer player	100
social worker	100
speech pathologist	100

steward	100
stock broker	100
superintendent	100
taxidermist	100
teaching aide	100
Texas ranger	100
trader	100

translator	100
transportation worker	100
treasurer	100
truck driver	100
vet tech	100
VP	100

warehouse manager	100
*wedding planner	100
wrestler	100
youth minister	100

Weapons

knives	4.761905
guns	5.263158
*bomb	9.090909
sword	10
*bow	14.28571
grenades	14.28571
arrow	16.66667
bat	16.66667
pistol	20
rifle	20
shot gun	25
tank	25
revolver	33.33333
rope	33.33333
3006 rifle	50
ak-15	50
ak-47	50
axe	50
brass knuckles	50
chemical	50
machine gun	50
nun-chucks	50
poison	50
22	100
12 gauge	100
20 gauge	100
45 auto	100
45mm	100

ak-12	100
army	100
assault rifle	100
*atomic bomb	100
bazooka	100
BB gun	100
biological	100
blow darts	100
bullet	100
bursa 380	100
canon	100
*claw	100
*club	100
commando	100
*crossbow	100
daggers	100
disease	100
drone	100
dynamite	100
explosive	100
fire	100
fire launcher	100
fist	100
flamethrower	100
Glock	100
halberd	100
hand gun	100
javelin	100

kali stick	100
katana	100
Katar	100
lance	100
m16	100
m1911	100
m416	100
mace	100
Macha	100
machete	100
missile	100
musket	100
needles	100
ninja star	100
nuclear	100
*nuclear bomb	100
pepper spray	100
pike	100
razor blade	100
rope line	100
RPG	100
Sai	100
scythe	100
semi auto	100
shank	100
short sword	100
sling shot	100
sniper	100

sniper rifle	100
spear	100
staff	100
stake	100
sub-machine	100

switch blade	100
syringe	100
Taser	100
throwing star	100
tomahawk	100

usas-12	100
vz1	100
whip	100
Winchester	100
wire sword	100

Metals

*silver	4.3478
copper	4.5455
*gold	4.5455
aluminum	6.6667
iron	6.6667
platinum	7.6923
steel	8.3333
*bronze	11.111
titanium	12.5
magnesium	14.2857
nickel	16.6667
tin	16.6667
cobalt	20
lead	25
zinc	25

manganese	33.3333
alkaline	50
*brass	50
mercury	50
alloy	100
antimony	100
barium	100
calcium	100
chromium	100
earth	100
liquid metal	100
lithium	100
palladium	100
potassium	100
precious	100

*rose gold	100
semi-precious	100
sheet metal	100
silicon	100
stainless steel	100
*sterling silver	100
strontium	100
sulfite	100
uranium	100
*white gold	100
zirconium	100

Fish

clown	4.5455
salmon	7.1429
gold fish	8.3333
catfish	10
shark	10
bass	11.1111
flounder	11.1111
tuna	11.1111
sword fish	12.5
*trout	12.5
beta	14.2857
tilapia	16.6667

angel	20
red drum	20
barracuda	25
*blow fish	33.3333
carp	33.3333
cod	33.3333
largemouth bass	33.3333
perch	33.3333
snapper	33.3333
*black mollies	50
*bluegill	50
drum fish	50

grouper	50
*guppy	50
lionfish	50
mahi mahi	50
marlin	50
minnow	50
molly	50
piranha	50
puffer fish	50
rainbow fish	50
red snapper	50
small mouth	50

bass	
white bass	50
algae eater	100
alligator gar	100
*blue tang	100
coy/koi	100
crappie	100
croaker	100
dolphin fish	100
dragon	100
eel	100
freshwater	100
gar	100
goblin shark	100

great white shark	100
*Guadalupe bass	100
halibut	100
king mackerel	100
mola mola	100
mullet	100
mulloway	100
pike	100
piper fish	100
*rainbow trout	100
sail fish	100
salt water	100
sardines	100

saw fish	100
sea horse	100
silver fish	100
snook	100
speckled	100
stingray	100
striped	100
sucker	100
sunfish	100
sunset molly	100
tiger barbs	100
upside-down catfish	100
yellow tang	100

Fruits

banana	4.1667
*orange	4.1667
apple	4.3478
strawberry	5
grape	5.5556
blueberries	6.25
*pineapple	6.6667
kiwi	7.1429
mango	7.1429
watermelon	7.1429
tomato	7.6923
cantaloupe	8.3333
blackberry	9.0909
raspberries	9.0909
*lemon	11.111
grape fruit	12.5
cherry	14.2857
honey dew	14.2857

papaya	14.2857
peach	14.2857
pear	14.2857
tangerine	14.2857
dragon fruit	16.6667
lime	16.6667
pomegranate	16.6667
melon	20
guava	25
plum	25
apricot	33.3333
avocado	33.3333
nectarine	33.3333
star fruit	33.3333
coconut	50
cucumber	50
berry	100
cactus	100

cranberry	100
durian	100
fig	100
gala apple	100
granny smith	100
kumquat	100
longan	100
lychee	100
*Mandarin orange	100
mangosteen	100
medlar fuit	100
passion fruit	100
persimmons	100
plantain	100
prune	100
zucchini	100

Drinks

water	4.1667
beer	5.5556
Coca-Cola	5.5556
sprite	6.25
dr. pepper	7.6923
apple juice	8.3333
lemonade	8.3333
orange juice	8.3333
tea	8.3333
wine	9.0909
coffee	10
milk	10
soda	12.5
Pepsi	14.2857
grape juice	16.6667
mountain dew	16.6667
hot chocolate	20
root beer	20
sweet tea	20
Gatorade	25
vodka	25
*whiskey	25
7up	33.3333
*alcohol	33.3333
cranberry juice	33.3333
crush	33.3333
rum	33.3333
smoothie	33.3333
sparkling water	33.3333
big red	50
coconut water	50
diet coke	50
energy drink	50
fruit punch	50
ginger-ale	50
green tea	50
iced tea	50

juice	50
liquor	50
PowerAde	50
punch	50
red bull	50
*ale	100
*all-sport	100
*almond milk	100
Beverly	100
big blue	100
*booze	100
bubble tea	100
Bud light	100
Budweiser	100
Canada dry	100
Capri sun	100
cappuccino	100
carbonated water	100
Chardonnay	100
cherry vodka sour	100
chocolate milk	100
cocktails	100
coconut milk	100
cognac	100
cola	100
Coors light	100
Fanta	100
Fanta pineapple	100
Fanta strawberry	100
flavored water	100
fruit juice	100
gin	100
gin and tonic	100
grape soda	100

Heineken	100
Hennessey	100
hi-c	100
jaeger	100
Kombucha	100
Kool-Aid	100
lager	100
lattes	100
lime juice	100
margarita	100
martini	100
milkshake	100
mineral water	100
mint julep	100
mixed drinks	100
monster	100
Mr. Pibb	100
orange soda	100
peach soda	100
peach tea	100
piña colada	100
prune juice	100
red wine	100
Sam Adams	100
shake	100
Shiner	100
sierra mist	100
soy milk	100
spirits	100
sprint	100
tequila	100
unsweet tea	100
vegetable	100
*white wine	100
yoo-hoo	100

Insects

ant	5.5556
fly	5.8824
butterfly	6.6667
beetle	7.6923
*mosquito	7.6923
*grasshopper	8.3333
caterpillar	9.0909
*cockroach	10
lady bug	11.111
bee	12.5
moth	14.285 7
praying mantis	20
wasp	20
cricket	33.333
fruit fly	33.333
dragon fly	50
honey bee	50

house fly	50
June bug	50
stink bug	50
walking stick	50
worm	50
*Aedes aegypti mosquito	100
black ants	100
black fly	100
bot fly	100
bumblebee	100
carpenter ant	100
cicada	100
click beetle	100
dirt diver	100
dung beetle	100
fire ants	100
firefly	100

flea	100
gnat	100
horsefly	100
katydid	100
kissing bug	100
lice	100
locust	100
maggots	100
mayfly	100
meal worms	100
no-see-um	100
rhino beetle	100
sugar ants	100
termite	100
tse tse fly	100
water bug	100
yellow jacket	100

Trees

oak	4.3478
pine	5
apple	6.66667
maple	11.1111
cedar	12.5
palm tree	16.6667
evergreen	20
orange	20
pecan	20
mesquite	25
*redwood	25
willow	25
cherry-blossom	33.3333

coconut	50
deciduous	50
*elm	50
live oak	50
magnolia	50
peach	50
ash	100
Ashe juniper	100
aspen	100
avocado tree	100
birch	100
blueberry	100
bois d'arc	100
bonsai	100

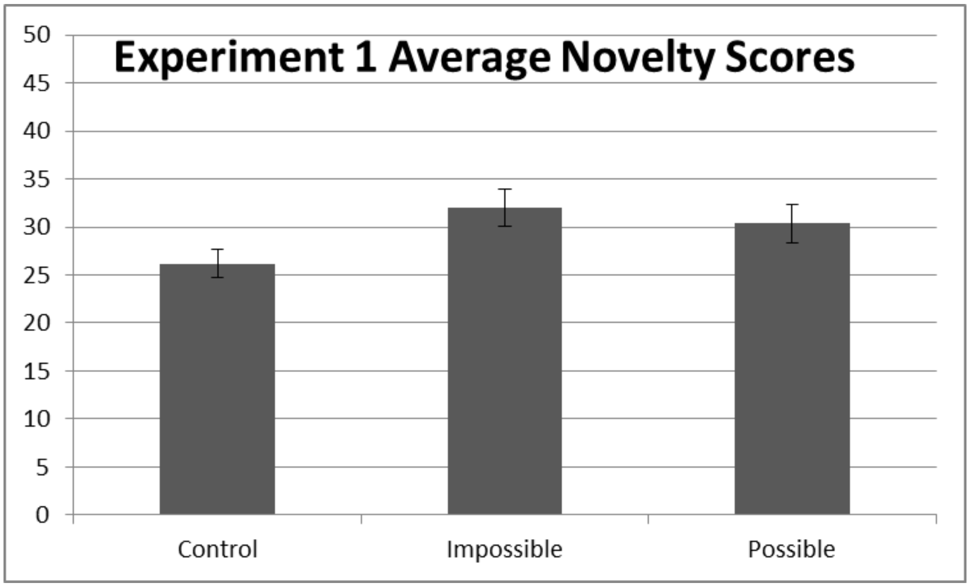
century	100
cherry	100
china berry	100
Chinese plum	100
Christmas	100
cotton wood	100
cypress	100
fern	100
fig	100
fir	100
Fraser	100
fruit trees	100
ginkgo	100

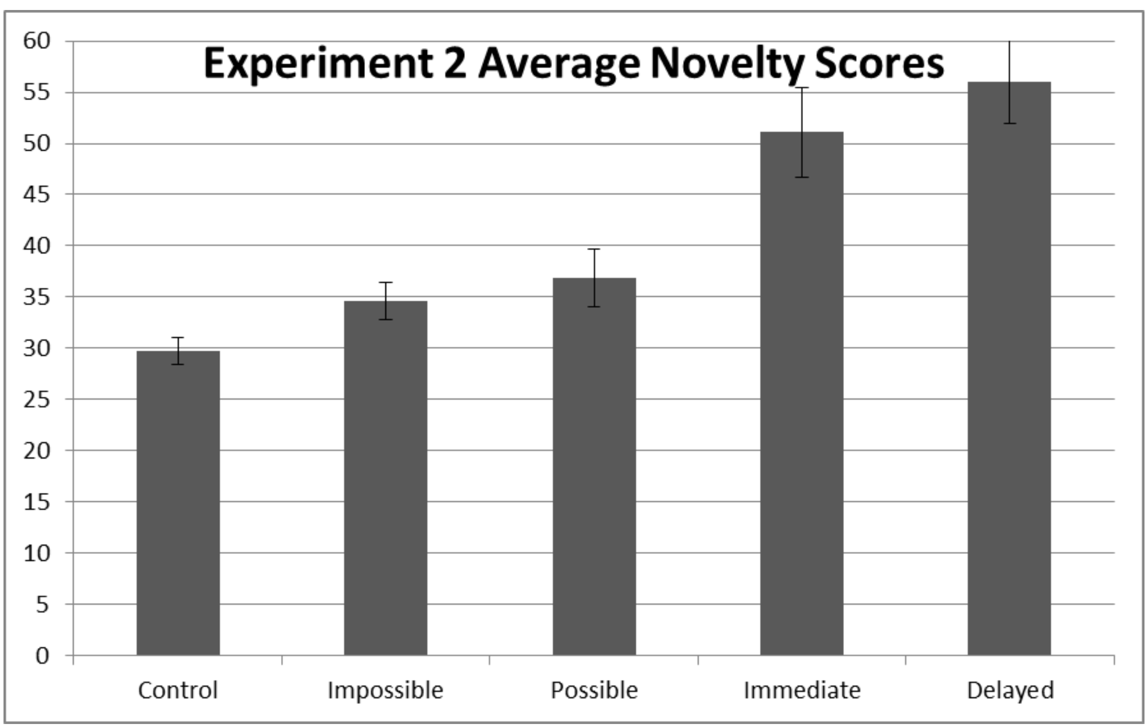
grapefruit	100
hickory	100
juniper	100
lemon	100
lime	100
mahogany	100
mango tree	100
mulberry	100

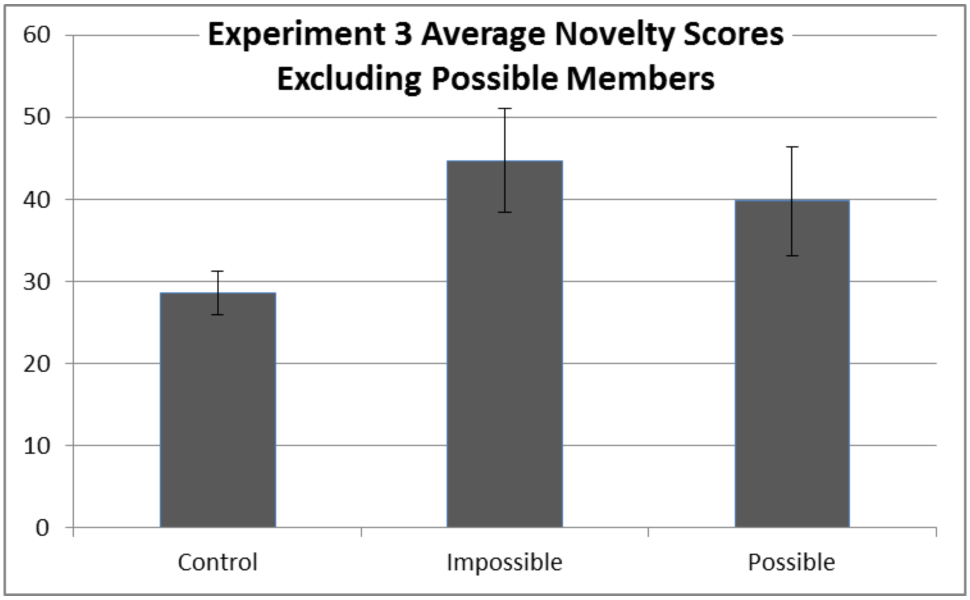
olive	100
pear	100
pin oak	100
plum	100
post oak	100
rain tree	100
*red oak	100
sequoia	100

*Spanish oak	100
*spruce	100
sweet gum	100
sycamore	100
walnut	100
weeping willow	100
white oak	100

APPENDIX D


Experiment 1 Average Novelty Scores
50
45
40
35
30
25
20
15
10
5
0
Control
Impossible
Possible


Experiment 2 Average Novelty Scores
60
55
50
45
40
35
30
25
20
15
10
5
0
Control
Impossible
Possible
Immediate
Delayed


Experiment 3 Average Novelty Scores
Excluding Possible Members
60
50
40
30
20
10
0
Control
Impossible
Possible